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Report of the PSARC Invertebrate Subcommittee Meeting July 7-10, 1997 and the Steering Committee Meeting August 19, 1997

M. Stocker and B. Holtby (Editors)
Pacific Stock Assessment Review Committee (PSARC)
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

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PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

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I. STEERING COMMITTEE REPORT

PSARC Steering Committee met 19 August, 1997 at the Pacific Biological Station, to review the Invertebrate Subcommittee report. The Subcommittee report was accepted by the Steering Committee. Steering Committee provided the following comments pertaining to general Subcommittee concerns, to individual Working Papers, and Fishery Updates summarized in the Subcommittee Report.

General Subcommittee Concerns

Subcommittee discussed five general issues regarding the assessment and management of invertebrate resources in the Pacific Region, in addition to consideration of the Working Papers. This discussion was intended to highlight strategic issues that impact regional stock assessment capabilities. Steering Committee commented that this practice is atypical among the PSARC Subcommittees. However, because of the diversity of invertebrate fisheries and demands that the development of new fisheries and the expansion of existing fisheries are placing on the Stock Assessment Division, the Steering Committee agreed that the Subcommittee discussion provided timely, cautionary information on assessment issues. In particular, Steering Committee wishes to highlight the following issues:

- PSARC is unable to provide advice for unregulated fisheries where data are limited or do not exist. Horse clams, octopus, opal squid, goose barnacle, and scallop have existing or proposed fisheries for which there are few data and no license controls. Interest in new invertebrate fisheries is likely to increase beyond those mentioned above.
- The lack of coordination among development groups in new and expanded fisheries could result in the Region agreeing to provide assessment support where there are no data or resources.
- While Steering Committee agrees that DFO should be involved in the British Columbia Partners program to ensure feedback to fisheries proponents about fishery development proposals, it does not agree that PSARC is the appropriate committee to provide that role.
- Steering Committee supports the Subcommittee recommendation to ensure that invertebrate bycatch is accurately recorded, particularly in those fisheries requiring observer coverage.
- Steering Committee advises RMEC of the Subcommittee proposal to conduct a regional workshop in mid-1998 to review the assessment and management framework for crab fisheries.

Steering Committee Discussion: Working Papers

The Subcommittee submitted ten Working Papers and ten Fishery Updates for consideration by the Steering Committee. Three Working Papers dealing with crab were deferred until the winter meeting of the Subcommittee due the absence of the primary author.

Working Papers I97-01, I97-03, I97-08: Phase 0 Assessments.

Working Papers representing Phase 0 assessments were completed for three species: Tanner crab (I97-01), Pacific Milky Venus Clams (I97-03) and oceanic squids (I97-08). These working papers represent the first stage of the framework for provision of management advice for new and developing invertebrate fisheries (Perry 1996) by summarizing available information on the target species and similar species.

Steering Committee endorses the recommendations of Subcommittee for each of these working papers. Commentary specific to each of the three Phase 0 working papers is listed below.

The Subcommittee recommendation for the development of criteria for measuring population responses to fishing was supported by Steering Committee in view of the unique biology of Tanner crab and the paucity of sustainable Tanner crab fisheries. Steering Committee agreed that the high discard mortality of this species highlighted the need to ensure that bycatch of Tanner crab is accurately recorded in other fisheries, notably trawl fisheries.

Steering Committee concurred with the potential for habitat disturbance noted by the Subcommittee for the Venus clam dredge fishery and the recommendation to involve Habitat Science in the monitoring component of the fishery.

Steering Committee recommended that the Director of Science investigate the potential for joint international assessment of oceanic squid stocks in preference to the Subcommittee recommendation that PICES undertake a comprehensive review of assessment and management.

Working Paper I97-02: Possible criteria for reopening the northern abalone (*Haliotis kamtschatkana)* fishery in British Columbia.

Steering Committee wishes to emphasize the findings of the Subcommittee that there is no evidence to support the resumption of the abalone fishery in British Columbia. Further efforts should focus on the evaluation of rehabilitation measures for this species and the implementation of effective deterrents to illegal harvest.

Working Paper I97-09: Evaluation of harvest models for Manila clam fisheries in British Columbia.

Steering Committee noted that the problem of defining management objectives for intertidal clam assessment models is ongoing. Consequently, Steering Committee endorses the recommendation for consultation with Fisheries Management to bound the scope of harvest strategy evaluation. Steering Committee highlighted the potential gains in assessment and protection of public health to be made by documenting catch by beach, noting the data is being collected by buyers and processors, but is not incorporated into current databases. Resolving this data issue in consultation with the Province, was judged to be tractable by the Subcommittee and Steering Committee.

Working Paper I97-10: Assessment of the 1995 Seal Island butter clam survey.

Steering Committee concurs with the Subcommittee decision to reject this Working Paper for the reasons cited in the Subcommittee report.

Working Paper I97-11: Assessment of the offshore *Pandalus jordani* trawl fishery off the west coast of Vancouver Island

Steering Committee accepts the Subcommittee recommendations for this working paper.

Fishery Updates

Fishery updates are prepared by Fisheries Management staff in consultation with C&P and StAD staff. The updates provide summaries of commercial fishery performance, including significant management, enforcement, and stock assessment activities on an annual basis. The updates also provide the opportunity to identify high priority issues that affect assessment and conservation concerns. Steering Committee considered each of the high priority issues and concurred that significant impacts on assessment capability or practice may result if these issues are not resolved.

II. INVERTEBRATE SUBCOMMITTEE MEETING

1. Introduction

The Subcommittee met in Nanaimo at the Pacific Biological Station from July 7 to July 10, 1997. The Subcommittee reviewed seven Working Papers and 10 Fishery Updates. Three additional Working Papers were received, but due to the absence of the senior author, their review was deferred to the next meeting, to be held in January 1998.

2. General Subcommittee Concerns

The Subcommittee discussed five issues of general concern to the assessment and management of invertebrate resources in the Pacific Region.

Unregulated, Data-limited Fisheries

A combination of:

- the lack of data,
- the absence of effort restriction,
- growing interest in fisheries expansion,
- changes to the management of traditional fin-fish fisheries and restricted opportunities in those fisheries, and
- evidence for either significant undocumented catch or the potential for the uncontrolled expansion of catch,

led the Subcommittee to be concerned with the situation in five existing fisheries, as summarized in the following table, and discussed in detail on page 30.

The Subcommittee strongly cautions that it cannot determine whether these fisheries are sustainable, and suggests that the imposition of license limitation and biologically based management are both necessary and suitably precautionary.

License limitation would require increased levels of consultation with stakeholders, as is the case for all licensed fisheries. A move to active management of these fisheries (biologically based fisheries management), which begins with a "phase 0" review[1], would place an additional strain on the Shellfish Assessment Section within Stock Assessment Division.

The Subcommittee strongly cautions that, without adequate resourcing of stock assessment activities for these species, it will be unable to provide advice on sustainable harvest levels in these fisheries.

[1] Perry, R. I. 1996. A framework for providing scientific advice for the management of new and developing invertebrate fisheries. PSARC Working Paper I96-6. Abstract of this Working Paper is reproduced in Appendix 6, page 43.

species	concerns	potential value	recommendation	notes
horse clam	-increasing demand -interest in development of fishery -habitat damage -potential user group conflicts (diver vs. inter-tidal harvesters)	high	1. priority phase 0	-amenable to assessment framework used for geoduck -limited to 'G' (geoduck) license holders
octopus	-poor performance of fisheries elsewhere -growing interest in fishery -no effort limitation -expanding catch	medium	1. priority phase 0 2. license limitation 3. imposition of effort controls in directed fisheries 4. report of bycatch in trawl fisheries	-until recently almost exclusively a bait fishery but there is growing interest in a higher-value food fishery
opal squid	-increases in numbers of licenses issued -number of licenses not reporting catch increasing	low	1. priority phase 0 2. license limitation	-rapid expansion in catch possible
goose barnacle	-number of non-reporting licenses increasing -fishery performance deteriorating -interest in dive fishery	high	1. license limitation 2. catch reporting	-possibility of substantial undocumented catch -interest by First Nations
scallop	-stable license numbers, most non-reporting -increasing catch -evidence of local depletions	medium	3. license limitation 4. catch reporting	-rapid expansion of catch possible -not a high-value scallop but steady demand -local over-fishing may exist

Coordination of development groups involved in new and expanded fisheries

The following table is a brief, and possibly incomplete, summary of the proposed new or expanded invertebrate fisheries in the Pacific Region and the associated coordinating or advocacy groups.

species	groups involved
1.abalone (aquaculture) 2. box crab	BC Ministry of Agriculture, Fisheries & Food (mostly through their BC Partners

species	*groups involved*
3. mussel 4. oceanic squid 5. purple urchin 6. Tanner crab 7. Venus clam 8. whelk	in Progress program), Sointulla Whelk and Box Crab Association.
9. octopus	Octopus Development Institute, Human Resources and Development Canada (HRDC)
10. inter-tidal clams, Savary Island	HRDC
11. shrimp	BC, Ottawa DFO through Fishing Industry Development
12. turban snail, limpet, whelk	private individuals

The Subcommittee notes that for some species, activities were undertaken (4, 5, 9, 10, 11) or proposed (9) with no prior consultation with either assessment or fisheries management in the Pacific Region. The Subcommittee advises regional management that the pursuit of new fisheries or the expansion of existing fisheries have significant assessment and management consequences to DFO. The Subcommittee advises that assessment capabilities within DFO are already over-extended with current fisheries, and that the startup of new fisheries, or the expansion of existing fisheries, cannot be accommodated with current resource levels.

The Subcommittee recommends that PSARC should be included in the referral process for the British Columbia Partners Program. Inclusion of PSARC in the early stages of this Provincial program would lead to timely feedback to fisheries proponents about the practicality and feasibility of fisheries development proposals.

The difficulties of inter-agency, inter-governmental and public communication, outlined above, highlight the need to proceed with the Fisheries Diversification Board, as identified in the Canada-B.C. MOU. Creation of this board should lead to clarification of the consultative process for the development of new fisheries and the expansion of existing fisheries, and should also make clear who is involved in that process. However, the Subcommittee advises that DFO assessment capabilities are currently inadequate to deal with the demands likely to be imposed by this process, which will, in turn, limit PSARC's ability to advise on the sustainability of those fisheries.

<u>Resourcing of assessment activities necessitated by Canada-BC MOU</u>

The Subcommittee has instituted a framework for the orderly expansion of existing

fisheries and the development of new fisheries[1] but strongly cautions that without immediate resourcing of this process it will have limited ability to advise on the sustainable harvest these invertebrate resources.

Deep-water trawl fishery for slope rockfish

During discussion of I97-1, the Subcommittee was made aware of a developing deep-water trawl fishery for slope rockfish that may increasingly encompass the habitat of Tanner crab. The Subcommittee acknowledges that this is an expansion of an existing fishery. The Subcommittee recommends that potential conflicts, such as bycatch of Tanner crab, should be investigated prior to the approval of new fisheries and the expansion of existing fisheries. Further to this concern, the Subcommittee recommends that the accurate and complete reporting of invertebrate bycatch should be a rigorously enforced requirement of license in all fisheries, especially in those fisheries requiring observer coverage.

Crab assessment and management

Three Working Papers were received prior to the summer meeting, but their review was deferred to January because of the inability of the senior author to attend the Subcommittee meeting. Two additional papers are anticipated for the January Subcommittee meeting. In the opinion of the Subcommittee, a critical review of the assessment and management frameworks for crab fisheries in the Region is needed. The Subcommittee proposes that such a review be conducted through a regional workshop to be conducted in mid-1998, possibly in conjunction with the 1998 summer meeting of PSARC.

3. Working Paper Summaries, Reviews and Discussion

I97-1 Biological background for the development of a new fishery for the grooved Tanner Crab (Chionoecetes tanneri) off British Columbia. A. C. Phillips and R. Lauzier.

Summary

The objective of this paper is to review what is known of the biology and fishery for the grooved Tanner crab, *Chionoecetes tanneri,* as the first phase towards developing a new fishery for this species. Specific information was collected from past and present

fisheries for this species and fisheries that recorded *C. tanneri* as bycatch. Additional information from research activities and museum collections is also included. Literature on aspects of life history of, and fisheries for related species is extensively reviewed and applicability of this information to a potential fishery for *C. tanneri* is considered.

The stocks of *C. tanneri* are not presently defined, however no other fisheries[2] have had a direct impact on stocks due to this species deep distribution (>500m). Therefore, any fishing will impact a virgin biomass. As such, information collected at the beginning phase of this fishery will be of extreme importance in subsequent stock assessment and management. From our review of other and similar fisheries, it appears likely that *C. tanneri* cannot be managed solely with size and sex limitations. Aspects of the life history and reproductive process should be considered in order to develop a risk-averse harvest strategy.

Reviewers' Comments

Reviewer 1 was generally complimentary about the overall scientific merit of the manuscript and provided a number of editorial comments. The reviewer questioned the objectives of the paper, given that so little is known about the species. The reviewer concurred with the authors that it is essential that surveys and commercial samples include the collection of both carapace width and one chela dimension, supporting the opinion that chela width may be a more appropriate gauge than carapace width to regulate a size limit to target mature males.

Reviewer 1 concurred with the authors that recruitment is likely sporadic and suggested that recruitment dynamics will become evident from changes noted in catch-rate/biomass, hard-soft shell and morph ratios and size frequency distributions in males as the fishery proceeds. Emphasis should be made to follow concomitant changes in females by utilizing shell state, fecundity, spermathecal contents, mating marks and egg viability to begin to understand first fecundity and then recruitment dynamics. Managers should be able to rapidly respond to what the stocks are doing given that predictive capabilities will (initially) be low.

Reviewer 2 was generally complimentary, provided some editorial comments, and thought that the information requirements and recommendations were well summarized. The reviewer suggested the addition of a clear explanation of what actions would be required to estimate mortality rates. The reviewer commented further

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[2] with the possible exception of a developing, deep-water trawl fishery on slope rockfish. See "Deep-water trawl fishery for slope rockfish", on page 9.

that "Biologically sensitive areas" should be defined, and suggested that the authors should include suggestions for how one might calculate an allowable harvest. The reviewer also recommended that the authors define the monitoring required to gauge the effectiveness of applied management actions, and suggested re-survey of fished areas, and the monitoring changes in CPUE or size distributions.

Subcommittee Discussion

The Subcommittee was satisfied with the scope and thoroughness of this paper and considered it a fine example of a 'phase zero' assessment.

The Subcommittee noted that these comments and recommendations apply only to *Chionoecetes tanneri*, and not to other members of the genus.

Much of the discussion centered on describing potential management tools and bounds for a fishery. Suggestions included the use standardized gear from the outset, trap limits, ensure the inclusion of a rot panel requirement and escape rings. The Subcommittee noted that the assessment/management frameworks developed for sea cucumber might be generally applicable to Tanner crab. The key characteristics of that framework were exploratory (i.e. experimental) fishing within a restricted area, and no fishing within a larger area, coupled with intensive monitoring of the population response to fishing.

A critical point of discussion centered on possible management strategies for the fishery. Evidence for this species, and other Tanner and King crabs suggest that discard mortality may be extremely high. If that were the case then management through sex and size limits alone may be insufficient to ensure a sustainable fishery. Consideration could be given to establishing a precautionary TAC, possibly with the use of CPUE data from Alaska, if available.

The similarities in other collapsed fisheries, as well as problems in the King and Tanner crab fisheries in Alaska and the Snow crab fishery on the east coast, should be characterized so that similar mistakes can be avoided in the Pacific Region.

Market concerns for establishing a size limit may also need to be taken into consideration, as well as license allocation issues. There is a potential by-catch concern for Tanner crabs in the newly developing groundfish trawl fisheries for *Sebastolobus* sp. (thornyheads).

Editorial comments included a request for more detail about both the New and Developing Fisheries Policy and the New and Developing Fisheries Stock Assessment Framework. Joint funding by MAFF should be referenced, definitions of "fishing down" should be included, and "non-destructive gear" changed to "selective versus non-selective gear".

Subcommittee Recommendations

The Subcommittee accepted the paper subject to minor revision, and makes the following recommendations:

1. The Subcommittee notes that there are examples of failed fisheries, but only one example of a sustained fishery on Tanner crabs. For this reason alone, the Subcommittee urges extreme caution in the development of fisheries on Tanner crab.
2. Because there are examples in the NE Pacific of failed fisheries on Tanner crab, the Subcommittee recommends that there be a thorough and critical review of the circumstances surrounding those failures, prior to development of a fishery in B. C.
3. The Subcommittee advises that conventional approaches to crab management ("size+sex" limitations or "size+sex+season" limitations) are unlikely to be successful for Tanner crab because of the unique features of Tanner crab reproduction and reproductive behavior, and because of the suspected high mortality of discarded Tanner crab. The Subcommittee therefore recommends that alternative assessment and management approaches be explored.
4. The Subcommittee notes that assessment based on Catch Per Unit Effort (CPUE) would benefit from the early imposition of standardized gear and recommends this be undertaken from the outset, should a fishery be developed on Tanner crab.
5. The Subcommittee stresses that the accurate reporting of bycatch of invertebrate species is important to precautionary and risk-averse management. In particular reference to this species, the Subcommittee stresses that the accurate reporting of invertebrate bycatch in deep-water trawl fisheries and in the sablefish trap fishery would be crucial to assessment and management of Tanner crab. The Subcommittee therefore recommends that measures be adopted to insure the accurate reporting and timely processing of invertebrate bycatch in all commercial fisheries.

I97-2 Possible criteria for reopening the northern abalone (*Haliotis kamtschatkana)* fishery in British Columbia. A. Campbell.

Summary

This paper reviews the literature for relevant biological and fishery characteristics of various abalone species, makes yield and egg per recruit calculations and suggests biological reference points, criteria for reopening a potential fishery, and possible rehabilitation and management actions for the northern abalone, *Haliotis kamtschatkana*, in British Columbia.

The biology of the northern abalone seems to encourage over exploitation. This species is slow growing with relatively high longevity, relatively sedentary, and has low or sporadic recruitment with accumulations of older individuals distributed in easily accessible shallow water locations. The high unit value, reduced availability and the difficulty of enforcing the fishery closure since 1990 in a large mostly uninhabited coastal area threatens the northern abalone to population collapse through illegal exploitation, hampering attempts to rebuild stocks to a level that would allow a sustainable harvest. Evidence to date from surveys in the central coast of British Columbia, and in the Queen Charlotte Islands, indicate that there has been insufficient recruitment during the last two decades to maintain fishing rates (F) during 1976-90, when the fishery was open (mean F about 0.5), and during the closure 1990-94 (F ranged from 0.1 to 0.7 in some locations), probably due to illegal poaching harvest. Samples from poached abalone suggest that poachers remove all sizes of available abalone with, no regard to the minimum size limit of 100 mm shell length that was in force during the legal fishery. Without size and fishing rate controls, egg per recruit (EPR) analyses suggest that egg production during the closed fishery could probably be at or less (<30% EPR) than the level when the fishery was open (30 - 50 %EPR). Many of the long-term abalone fisheries around the world that have conserved $\geq$ 50%EPR have been sustained; other fisheries that conserved lower egg production have suffered poor recruitment, stocks have declined and many fisheries closed. However, because of the difficulties of showing a stock-recruitment relation and predicting how environmental and ecosystem changes influence abalone stock dynamics, there are no guarantees that various rebuilding or rehabilitation strategies will work.

Criteria for the reopening of even a limited northern abalone fishery could include (1) evidence for sustained rebuilding over an area sufficient to maintain a large meta-population of northern abalone, (2) maintenance of the abundance and distribution of spawners and recruits to a level of at least 50% of virgin densities, and (3) management and monitoring of the fishery sufficient to insure a low fishing rate (e.g., $F < 0.1$) and, (4)

high minimum legal sizes sufficient to insure high egg production (e.g., 70 - 80 % EPR).

The rehabilitation of northern abalone populations could involve (1) a continued fishery closure until stocks rebuild, (2) the reduction of illegal harvest through increased public awareness, (3) the encouragement of local community participation through monitoring and management of experimental management areas at small spatial scales, and (4) the enhancement by brood stock transplants and juvenile seed restocking.

Reviewers' Comments

Reviewer 1 provided a favorable review and complimented the author for his review of the literature and modeling techniques. The reviewer noted that there was no discussion regarding benefits or consequences of each of the options presented in section 7 and figures 3-5. Reviewer 1 also commented on the lack of discussion around survey methodology, and suggested temporal and spatial survey components may be critical to evaluating reopening criteria and/or experimental management areas.

Reviewer 1 pointed out two additional points for clarification. First, the reviewer asked how relevant comparisons of *H. laevigata* in south Australia were with stocks here in British Columbia. The second point suggested the paper clarify terminology in terms of defining "pre-recruits".

Reviewer 2 also provided a very favorable review of the paper, and echoed the first reviewer's comments about the excellent review of current literature on the species. The reviewer complimented the author on his state of the art analysis. Reviewer 2 stressed, drawing from similar experiences in California that work relating to this species should be directed towards preventing further declines in population abundance or distribution, and should not be concentrated on developing criteria for re-opening the fishery.

The reviewer was concerned with the lack of analyses describing animals smaller than 70mm, and suggested that signs of recruitment failure could be first detected in smaller, younger animals. The final point made was that a review of environmental factors might be a means of further insight into recruitment.

Subcommittee Discussion

There was discussion on the use of the term "egg-per-recruit (EPR)" in the modeling sections of the WP. The consensus was that this term was confusing, and that the term needed further explanation and clarification. The Subcommittee discussed the possibility of measuring larval settlement on concrete blocks to index the abundance of pre-recruits. The author agreed that this could be one possible method, but would require experimental testing.

The Subcommittee attempted to "rank" the importance of each of the possible re-opening criteria listed in Campbell's paper, but concluded that such ranking could not be determined from the information presented in the Working Paper. Furthermore, the Subcommittee concluded that there was insufficient information available to determine the appropriate spatial scale for a density criterion.

The Subcommittee further discussed the extent of the conservation problem, and factors that are most likely to adverse affect the recovery of abalone. Specifically discussed were the evidence of large-scale illegal harvest and the difficulties with enforcement arising from the (legal) importation of abalone product into B. C., which enables the laundering of abalone illegally harvested in B. C.

The Subcommittee discussed the seriousness of conservation concerns for abalone and the need to take pro-active initiatives to rebuild stocks throughout the coast. It was noted that recent surveys and stock assessment activities have taken place in cooperation with First Nations, and it was suggested that this process may assist in encouraging local community participation, protection of abalone in the surveyed sites, and education about the status of abalone.

Subcommittee Recommendations

The Subcommittee accepted the paper subject to minor revisions.

1. The Subcommittee emphasizes that there is no evidence to alter past advice on conservation concerns with northern abalone.

2. The Subcommittee advises that with current levels of mortality, most of which is presumed to come from illegal harvest, **there is no prospect for the resumption of fisheries in the near future**. This conclusion is based on information presented

from other abalone fisheries, in conjunction with modeling of minimum spawning potential.

3. The Subcommittee recommends that the results of the recent surveys (1997) be presented in a Working Paper at the January 1998 meetings.

4. **The Subcommittee advises that the conservation status of abalone is unlikely to improve unless meaningful measures are instituted to stem the illegal harvest.** Such measures are a necessary first step to the rehabilitation of abalone.

5. The Subcommittee strongly concurs with the reviewer who urges DFO to acknowledge the conservation concerns for northern abalone and to place emphasis on rehabilitative measures for the species, rather than on the establishment of criteria for reopening fisheries. To that end, the Subcommittee recommends that an experimental approach be undertaken to enhance abalone and to determine parameters related to spatial scale and abundance, which are thought to be the critical factors in reproductive success. The Subcommittee acknowledges that enhancement would require brood-stock collection, and that experimentation would likely involve the manipulation of abalone densities in the wild. Both activities must be carefully monitored to preclude further damage to northern abalone.

I97-3 A Review of the biology of the Pacific Milky Venus clam (*Compsomyax subdiaphana*) and the fisheries of related subtidal species. R. Lauzier.

Summary

A review of the biology on the Pacific Milky Venus clam *Compsomyax subdiaphana* was conducted from previous surveys, scientific literature, technical reports and consultant reports. Where there was little or no existing information, a review of the biology of similar species was conducted from the scientific literature and stock status reports.

A review of previous fisheries on similar species was conducted, focussing on East Coast stocks, where there is a history on the mechanical harvests of subtidal clam stocks, and where there are developmental fisheries on sub-tidal clam stocks. Stock assessment and management strategies from previous fisheries were reviewed. Recommendations for additional information requirements for stock assessment are given.

Reviewers' Comments

Reviewer 1 felt that the author had largely achieved the objectives of a phase 0 review for a new and developing fishery. The reviewer acknowledged the fact that there exists little direct information on this species, and that a large amount of inference from other species and fisheries had been made, not all of which was appropriate in the opinion of the reviewer. The reviewer felt that a precautionary approach to the fishery was warranted and that we need to remember that the skills of the fishers will develop with experience in the fishery. The reviewer felt that there was a requirement for more discussion on the habitat issues associated with this fishery. Important questions still exist as to the exact habitat changes due to a dredge fishery, the duration of those changes, and the survival of Venus clam and other affected species after dredging. The reviewer recommended that estimates of the mortality rate and virgin biomass be made. Specific recommendations included the verification of age data, sampling by grab as well as dredge to verify the dredge efficiency, more discussion of the specifics of the limited dredge fishery in Washington on sub-tidal, little neck clam, and specific details on how to collect information from the fishery (i.e. logbooks, biological sampling etc.).

The second reviewer questioned the appropriateness of making explicit inferences from other species as to life history and fisheries. The reviewer felt that the discussion and literature review of related species could be eliminated, and felt that the comparison to littleneck clams was completely inappropriate. The reviewer recommended that any aging done to date on this species be validated. As there is little direct information on the Venus clam, the reviewer recommended the inclusion of a section that specifies the minimum DFO knowledge requirements before a fishery on this species can take place.

Subcommittee Discussion

The Subcommittee concurred with the observation made by reviewer 2 that the abundance and distribution of known commercial concentrations of Venus clam are limited within B. C., and that the species is unlikely to support a large enough fishery to support an intensive (hence expensive) assessment program. Such a program would be required to establish a recruitment-based assessment approach for this species.

The Subcommittee discussed at length potential habitat impacts and the mortality issues associated with this fishery. The Subcommittee noted that Venus clams have a very thin shell, which suggests that few individuals would survive dredge harvesting. The ability of individual clams to rebury after disturbance is unknown. For these reasons, the Subcommittee thought it was unlikely that a conventional size-limit approach would be appropriate, and that other approaches need to be investigated.

The Subcommittee discussed uncertainties regarding the productivity of deep water clams and agreed that priority information needs for the species were to confirm ages derived from shells and for biosampling to determine growth rates and fecundity.

Subcommittee Recommendations:

The Subcommittee accepted the paper subject to substantive revisions.

1. The Subcommittee notes that there is potential for considerable habitat disturbance associated with dredging and recommends that Habitat Science be involved in the monitoring component of this fishery;

For development of this fishery, the Subcommittee recommends that:

2. the fishery be confined, for the time being, to a limited number of sites within the southern Strait of Georgia;

3. that an estimate of the natural mortality in these areas be made using a variety of methods to assist in determining a conservative fisheries mortality;

4. that a range of fishing mortalities be applied across the selected sites while excluding some of the high-density sites from harvest (Perry 1996[1]), and

5. that the responses of the populations in harvested and non-harvested areas be monitored.

I97-8 Review of biology, fisheries and assessment of North Pacific oceanic squids, particularly *Ommastrephes bartrami, Onychoteuthis borealijaponica, Gonatopsis borealis* and *Berryteuthis magister.* G. E. Gillespie.

Summary

Four species of oceanic squid, neon flying squid (*Ommastrephes bartrami*), boreal clubhook squid (*Onychoteuthis borealijaponica*), eight-armed squid (*Gonatopsis*

borealis) and schoolmaster gonate squid (*Berryteuthis magister*) were designated as target species in a pilot fishery to evaluate the potential for development of an automated jig fishery for squid off British Columbia. This paper reviews available literature on the biology, fisheries, assessment and management of oceanic squid species, particularly the four target species.

Assessment and management of squid species are complicated by variable recruitment, oceanographic effects on distribution and availability, extensive migrations, short (usually annual) life cycle, and semelparity. More information is required regarding life history, population structure and dynamics of these species in the eastern North Pacific.

The paper reviews information requirements for rational assessment and management of fisheries on these species, outlines priorities of an assessment program, and provides management considerations from the literature.

Reviewers' Comments:

The reviewer commented on the reversal of the phase (1) experimental fishery with the phase (0) review, but was of the opinion that the consequences were likely not significant at current levels of effort, vessel capacity and efficiency. The reviewer also felt that consideration of fisheries on other squid species might be of limited utility in designing a Canadian oceanic squid fishery. The reviewer would like to see a more specific description, in point form, of the information requirements that a phase (1) fishery should supply and how it can be obtained, but was not optimistic about relying on the commercial fleet for insight into flying squid biology. The reviewer pointed out that decadal-scale fluctuations may be large and wondered whether fishers' interest in such a fishery would be affected if they were aware of it's potential instability. The reviewer questioned the suggestion that the species' short life-span makes it particularly vulnerable to overfishing, pointing out that very large annual catches in the past have not lead to signs of overfishing. It was postulated that other factors must exist that buffer the risk (but also notes that in-season monitoring would be recommended to protect the stocks from collapse). Finally, the reviewer noted the paper's lack of discussion on the international nature of this highly migratory species and the obligations that Canada has in terms of stock assessments and data exchange, if a fishery persists.

The second reviewer[3] was complimentary toward the biological components of the WP but felt that the author had not provided a clear assessment and management approach for oceanic squid. The important question is the stock structure of *O. bartrami*: are the animals off the Canadian coast from the same stocks as those in the central Pacific? The reviewer suggests that the discussion of the WP should be organized around assessment and management plans for *O. bartrami*, as that species is almost certain to be the focus of a jig fishery. The assessment should be tailored towards a widely migrating oceanic species, harvested towards the limit of its range, and previously subject to intense exploitation without detectable impacts. The reviewer suggests that although the other species are unlikely to be a major component of the fishery, the lack of data on those species would require careful evaluations of any fishery impacts, and may be the basis for a conservative harvest/bycatch plan.

Subcommittee Discussion:

The Subcommittee supported the comparison made with fisheries on other species in the world, but felt that more detail of those fisheries, with emphasis on the features that are comparable to local species, would highlight the lessons to be learned. There was general recognition that oceanic squids are an international fishery on highly migratory species, and that cooperation with other countries would be essential to developing an assessment and management approach. The Canadian oceanic squid fishery should be highlighted in PICES and that, ultimately, it should be managed within an international frame of reference. There was discussion on whether a Canadian fishery could do any damage to this stock, since it is unknown what portion of the stock the fleet is fishing on. There was agreement that stock delineation was a high priority information need.

The Subcommittee concluded that, in the immediate future, the fishery must continue to be managed in a risk-averse manner, i.e., with effort capped at current levels. It should progress in a stepwise fashion with catch and effort data being intensely monitored to chart progress of fishers' learning curve and to acquire better understanding of the productivity of the target species in the eastern Pacific.

The Subcommittee requested the following information be included in the revision of the paper:

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[3] The second review was not received in time for consideration by the Subcommittee. The summary was prepared by the Subcommittee Chair, who concluded that the review reinforced many of the points raised by the first reviewer and the Subcommittee during discussion of this paper.

1. more complete discussion of applicability of other fisheries experiences (e.g. Falklands)
2. highlighting of the extent of long-term variations in abundance and what potential implications of this are in a highly capitalized fishery,
3. highlighting of the short term biological information needs to come from intensive monitoring of the fishery (phase 1 of the phased approach to fisheries development)
4. expanded treatment of the implications of the short life span of these species to potential risks in an intensive fishery.

Subcommittee Recommendations

The Subcommittee accepted the paper with minor revisions.

1. The Subcommittee recommends that the collection of biological and catch-effort data be continued.

2. Oceanic squid are properly considered highly migratory stocks and only portions of the populations are found off Canada. Progress in the assessment and management of these species is possible only in an international forum such as PICES. The Subcommittee recommends that a comprehensive review of the assessment and management of oceanic squid be undertaken by PICES, with involvement of the appropriate Stock Assessment Division and Fisheries Management staff.

3. The Subcommittee advises that the long-term variation in abundance noted in oceanic squid will pose problems for the sustainability of a highly capitalized fishery. The Subcommittee further notes that the "learning curve" in this fishery is particularly steep, so there is potential for sudden and rapid escalation of efficiency once the current fishers determine where the squid are and how to fish them. For those two reasons, the Subcommittee strongly recommends the continuation of a very conservative stance in this fishery.

I97-9 Evaluation of harvest models for Manila clam fisheries in British Columbia. G. E. Gillespie and J. Bond.

Summary

A simple harvest model was used to evaluate the effects of various harvest rates on yields and stock size in Manila clam fisheries. Models used included the Washington State Department of Fish and Wildlife management program, depuration fisheries in British Columbia, and estimated harvest rates from size-limit fisheries. Data were taken from surveys completed by First Nations co-management programs.

Because recruitment patterns are not known for Manila clams, the models examined effects of the harvest rates on the stock detected in the survey, essentially the initial legal-sized stock and one year's recruitment.

The Washington State model is designed to partition the detected stock over a four-year harvest period. Models incorporating a size limit (constant harvest rates of 0.5 to 0.7) have the higher yield, but reduce stock size more quickly than other models. If recruitment is relatively good, size-limited fisheries deplete detected stock in 3-4 years, depending on harvest rate. Under fair or poor recruitment, size-limited fisheries deplete detected stock in 2-3 years. The model employing a constant TAC of 25% of the initial legal stock estimate depletes that stock in two, three or more than 4 years, depending on recruitment level. A 50% TAC model depletes detected stock in three, 2 or 1 year.

High harvest rates produce high yields, but are more quickly dependent on annual recruitment to maintain harvest levels. Total yield is reduced at lower harvest rates, but is more consistency.

Reviewers' Comments

Reviewer 1 noted that the current WP employs an instantaneous framework to model natural and fisheries components of the fishery. The reviewer was critical of the lack of either a biological or a management framework under which the modeling could be evaluated. For instance, the reviewer was uncertain whether the 4-yr model period is appropriate to the dynamics of the resource or has any bearing on the management of the fishery. The reviewer suggests that the formulation of management plans for Manila clams requires two things:

(1) an evaluation of management objectives relative to the dynamics of the resource. The reviewer suggested that enough information about the population dynamics of clams has been collected to make it feasible for DFO to formulate management objectives that are consistent with those dynamics. The reviewer illustrated this

point by referring to some of the harvest policies implied by the WP that would seem to include years where no harvest was possible. Without specific management objectives, it would be difficult to determine if those scenarios were feasible.

(2) the development of a more rigorous analytic model for the resource. The reviewer suggests that enough information on clam population dynamics has been gathered to allow the formulation of cohort-based models. The reviewer acknowledges that progress on requirement 2 will be difficult until all harvest is quantified.

The reviewer noted that the WP used numbers and weight interchangeably and that this was needlessly confusing to the reader.

Reviewer 2 suggested that the overall conclusion of the WP was somewhat obvious and that more substantive conclusions would not be possible without the articulation of biological or management objectives. The reviewer critiqued the paper in the context of Starfield (1997)[4]. Within that context, the WP has several major shortcomings, although the reviewer did emphasize that those problems were not attributable entirely to the authors. The reviewer noted that no reference points for evaluating harvest strategy, based on biology or other factors, were provided. The models presented do not allow for recruitment or allow only for constant recruitment. The models do not estimate stock characteristics at the end of the modeled period, limiting the evaluation of the models. The reviewer argued that the temporal component of the simulations was too short and didn't allow evaluation of the stability of any of the harvest strategies. The reviewer also indicated that the models need to be made stochastic.

Subcommittee Discussion

The Subcommittee concurred with the comment of both reviewers that the evaluation of any harvest strategy was dependent on clearly articulated objectives, regardless of whether they were biological, economic, or otherwise. The Subcommittee noted that the authors had made the substantial revisions requested of them following review of I96-10, and further noted that the current paper (I97-9) does present an analysis of the effects of various harvest rates on yield (magnitude and constancy), which were the essence of the management request for advice. The Subcommittee concluded that since the modeling approach used did not include recruitment or biological characteristics other than abundance, and operated over a short time frame, that the Subcommittee is unable to make recommendations on the larger issues of what constitutes appropriate assessment and management strategies for clam fisheries.

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[4] Starfield, A. M. 1997. A pragmatic approach to modeling for wildlife management. Journal of Wildlife Management 61(2): 261-270.

The Subcommittee concurred with the suggestion by both reviewers that future work in modeling clam fisheries should be pursued by incorporating stochastic recruitment processes in an appropriate age-structured modeling framework and notes that some progress is being made in this area.

As noted by the reviewers, progress in the assessment and management of inter-tidal clams is severely limited by DFO's continuing inability to quantify clam harvest by beach. The Subcommittee discussed measures that could be taken to improve harvest records in the depuration fishery but noted that undocumented, and largely illegal, harvest continues to impede improvement in the assessment and management of inter-tidal clams.

Subcommittee Recommendations

The Subcommittee accepted the paper subject to minor revision.

1. The Subcommittee recommends that StAD now proceed to more general simulation models incorporating recruitment processes that will allow:

   (a) the exploration of the consequences of varying recruitment,
   (b) the exploration of risk associated with various harvest rates, and
   (c) the consequences of undocumented harvest.

2. The Subcommittee notes that the boundaries of this modeling approach are broad, and that considerable efficiencies could be achieved if consultation with Fisheries Management could define a subset of plausible management objectives.

3. The Subcommittee notes the importance of documenting catch by beach and recommends that, in consultation with the Province, data systems be modified to allow the collection of catch and effort information by beach.

I97-10 Assessment of the 1995 Seal Island butter clam survey. J. Osborne and D. Heritage

Summary

Investigations into the butter clam populations of Seal Island, near Denman Island in Baynes Sound, southern British Columbia, have occurred since 1940. Seal Island

butter clams account for a large proportion of butter clam landings from Statistical Area 14. The commercial butter clam fishery at Seal Island was closed in the summer of 1994 due to concern that sub-legal stocks were low, and a stock assessment survey at Seal Island was completed in 1995 to investigate this concern. This paper presents the results of this survey and compares the results and methodology to previous surveys done at Seal Island. Both legal and sub-legal biomass and abundance estimates were found similar to those of the previous survey in 1992. Sampling methodology differed in the 1995 survey to that of previous surveys in that stratified random sampling was used and substrate was screened to detect very small clams. The implications of these methodologies are discussed.

A recruitment index, defined as the proportion of the total abundance estimate comprised of sub-legal clams, was calculated for all surveys from 1940-1995. The limitations of this index are discussed.

Biological data from six separate surveys (1980-1995) were fit to the Brody-von Bertalanffy growth model. Parameter estimates from all years except 1991 were similar although differences were not tested statistically. The apparent deviation of 1991 parameter estimates is thought to be due to small sample size used to fit the model. Potential uses of the Brody-von Bertalanffy model are discussed.

Recommendations regarding future Seal Island survey methodology, the Seal Island database and future research are made.

Reviewer's Comments

The reviewer cited a lack of background information explaining the assessment issue for Seal Island Butter clams. The lack of supporting biology for the selection of the proportion of sub-legal clams as a recruitment index was emphasized by the reviewer. The reviewer noted that potentially useful information on numbers at age available from the 1995 and historical surveys had been ignored. Specifically, a comparative analysis of pre-recruit numbers at age was recommended, as well as a treatment of subsequent post-recruit age structure. A discrepancy between the survey area in 1995 versus the survey area for historical data was noted. The paper contained an ambiguous explanation of how the screened samples were included in the biomass estimates and did not provide justification for the choice of the 40 mm detection size. The reviewer concluded that only one of three objectives had been satisfied; an estimate of the standing stock of sub-legal and legal Butter clams at Seal Island had been presented. The justification for the recruitment index was weak and there was an inadequate attempt to place the current stock conditions into the context of historical survey results.

Subcommittee Discussion:

The Subcommittee reiterated that the paper was initiated to address concerns over a possible recruitment failure of Seal Island Butter clams. The proportion of sub-legal Butter clams was proposed by the authors as a recruitment index, without consideration of data available on age and size distribution. Indeed, the authors appeared not to distinguish recruitment to legal size from biological recruitment. It was suggested that the paper did not contain advice useful for management of the Seal Island fishery. While the examination of 1995 survey data is a necessary component of the analysis, the objectives of the paper required that current stock status be compared to historical survey results. The comparison in the working paper largely consisted of computing a time series of the proportion of sub-legal clams. This was not judged an adequate treatment of the data. Information presented in Figures 3 and 4 was confused by presentation of biomass estimates where only summary data were available; i.e. the original survey data were reported as lost. In addition, lower confidence bounds for the biomass estimates were obscured on the figures. The stratified random sampling estimators are not strictly applicable to the 1995 survey data since the design was a stratified two-stage randomization with only a single sampling unit selected at the second stage. The effect of this problem on the estimates and confidence intervals is not immediately clear or explicitly acknowledged in the paper. The Subcommittee concluded that the paper did not represent an incremental improvement over I96-10 and consequently did not accept the paper.

The Subcommittee concluded that little progress had been made at advancing the analysis of the Seal Island data series. The Subcommittee notes:

1. that the recruitment index employed (ratio of sub-legal abundance and total clam abundance) cannot be used as a basis for making any judgment about the advisability of closing or opening the fishery, and that in consequence that the paper provides no useful advice to management;
2. that the survey method used was not a stratified random design and that the analyses performed by the authors was inappropriate, and
3. that the advice provided to the authors during the initial PSARC review of this WP was broadly ignored.

Subcommittee Recommendations

The Subcommittee rejected the WP because of methodological errors and the use of a

recruitment index that does not permit advice requested by fisheries management to be generated.

1. The Subcommittee advises that it remains unable to provide advice on criteria for managing the Seal Island butter clam fishery.

2. In the absence of any indication of a conservation concern for Seal Island butter clams, the Subcommittee recommends that Fisheries management continue with the conservative approach to setting a TAC for the fishery, which was adopted in 1996.

I97-11 Assessment of the offshore *Pandalus jordani* trawl fishery off the west coast of Vancouver Island. J. Boutillier, R. I. Perry, B. Waddell and J. Bond.

Summary

This paper provides the first overview and analyses of information on the offshore trawl fishery for *Pandalus jordani* off the West Coast of Vancouver Island. Data are analyzed from historical landings, fishing vessel logbooks, research surveys, and environmental monitoring stations to describe the distributions, growth, and population dynamics of these *P. jordani* stocks, and the history of their commercial fisheries. Two areas have predominated in the fishery: Tofino (Area 124) and Nootka (Area 125) grounds, with the offshore Barkley ground (Area 123) important in recent years. Information on growth and recruitment patterns suggests these grounds represent separate stocks. Analyses suggest the existence of a Ricker-type stock-recruitment relationship for the Tofino and Nootka stocks, with a strong component of additional variability related to environmental conditions associated with springtime wind forcing of the local circulation. Recommendations are made on additional sampling needed to resolve specific outstanding issues, and management options and considerations in light of these new analyses are discussed.

Reviewers' Comments

Reviewer 1 was generally complimentary, and thought that the extensive data summation was particularly valuable. The reviewer was concerned that gear and methods used in the research surveys were not keeping up with technological changes in the fishery. When coupled with a lack of sampling in the commercial fishery, the divergence of fishing gear should constrain the assumptions that can be made about

the age composition of the commercial catch. Of greater concern to the reviewer was the apparent difference between the areas covered in the research surveys and those actually fished by the commercial fleet. The reviewer strongly supported the collection of biological information from the fishery that could be used to generate age composition, and suggested alternative analyses for determining growth, mortality and yield of the stocks using that data. The reviewer was concerned that corrections to the survey data for vertical distribution of the shrimp may have been inappropriate. The reviewer questioned the calculation of CPUE from logbook data and the representativeness of logbook data. The reviewer questioned the exclusion of outliers in the stock-recruitment analyses and the validity of the degrees of freedom used in the analyses of environmental effects.

Reviewer 2 also thought that the paper was a strong start to the assessment of this fishery, but thought that several of the component analyses could be significantly improved. The reviewer thought that the stock-recruitment analysis was flawed by the use of a re-ordered Ricker analysis and provided an unpublished manuscript that discussed the statistical artifacts introduced by the re-ordering procedure[5]. The reviewer questioned the *a priori* use of a Ricker stock-recruitment and suggested that the authors provide a justification for choosing a Ricker function rather than a Beverton-Holt or Cushing function. The reviewer suggested that the authors do a more straightforward analysis of environmental factors to compare the explanatory power of environmental vs. stock-recruit models. The reviewer suggested that the authors should have been more inclusive in their analyses by including work that has been published on Oregonian shrimp, which were purported to show over-riding environmental control of recruitment. The reviewer questioned the stock structure of WCVI shrimp and doubted that there were several self-replenishing "stocks". The reviewer pointed out several difficulties with the choice of the recruitment index used, and indicated that the authors had not made a convincing case for the use of age 3 shrimp as an index of parental stock. In summation, the reviewer thought that a more extensive analysis of environmental factors, combined with a more empirical approach to defining any stock-recruitment relationship was required.

Subcommittee Discussion

This paper was prepared in response to a management request for advice regarding the appropriateness of active management in a situation where recruitment may be environmentally driven. Despite uncertainties with the statistical significance and appropriateness of the stock-recruitment analysis presented, the Subcommittee felt that

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[5] Hankin, G., 1987. The merits of a stock-recruitment analysis for Oregon's north coast fall chinook salmon, unpublished report for Oregon Dept. Fish and Wildl. 10p.

there was sufficient evidence of a stock-recruitment relationship to conclude that the assumption that recruitment was driven entirely by the environment was risk-prone.

The Subcommittee concurred with the reviewers about the importance of continuing the fishery-independent surveys and collecting age composition and other biological information from the commercial fishery.

The Subcommittee discussed indications of fishery impacts on WCVI shrimp that were identified in the WP, namely:

(a) continuing decreases in the biomass index
(b) changing age structure with loss of older animals
(c) variability in fishing areas, suggesting large variation in stock abundance and distribution with time. (It is unknown whether this is due to fishing pressure, larval movement, or spatial variation in recruitment)
(d) a change in fleet composition from a few very large boats to a larger fleet of much smaller ones (smaller boats can fish profitably at lower abundance levels than larger ones), and
(e) the increased use of selective gear allowing entry in new fishing areas.

The Subcommittee was particularly concerned with the tendency in this fishery to maintain catch levels during periods of declining abundance. Although both reviewers questioned the appropriateness or validity of the stock-recruitment analyses provided by the authors, the Subcommittee felt that there was sufficient evidence of an underlying stock-recruit relationship to recommend a continuation of the precautionary stance adapted in 1995 and continued in 1996.

Subcommittee Recommendations:

The Subcommittee accepted the Working Paper with major revision.

1. The Subcommittee recommends that the pre-cautionary measures already instituted be continued.
2. The Subcommittee advises that to pursue pre-cautionary and biologically based management of this resource, it will be necessary to:
   (a) collect catch-at-age information from the commercial fishery, and
   (b) continue fishery-independent surveys areas 124 and 125 and to include areas 121, 123 and 23 in the survey program.

4. Fishery Updates

Fishery Updates are prepared annually by Fishery Management staff in consultation with C&P and StAD. Fishery updates are summaries of commercial fishery performance, including significant management, enforcement and stock assessment activities during the preceding year. The Invertebrate Subcommittee uses Fishery Updates to identify and discuss significant assessment and conservation issues in each fishery, and especially those for which no Working Paper was presented.

<u>High priority issues arising from Fishery Updates</u>

There are five fisheries for which general and specific concerns exist, that lead the Subcommittee to recommend immediate imposition of effort controls through license limitation. It is the opinion of the Subcommittee that **the continued approval of passively managed fisheries, in which entry is unlimited and effort is not constrained, is entirely inconsistent with precautionary and risk-averse management**. The Subcommittee also recommends that several of these species be formally entered into the assessment portion of the framework for "*the provision advice for the management of data-limited fisheries*" (Perry 1996), referred to below as the "phased approach to fisheries development".

<u>Horse clam</u>: There are two species of horse clam in BC waters, both of which potentially have high values on the live market. The Subcommittee notes that *this is probably the most valuable of the potential new fisheries.* Both species are primarily sub-tidal but are found in abundance in the inter-tidal zone where they co-occur with commercially harvested species such as butter clam. In some areas, notably Seal Island, horse clams are either discarded or illegally processed as butter clams. Both species can be abundant in eelgrass beds where harvest would likely disturb this sensitive ecological zone. *This habitat association is currently the major limiting factor to the development of a fishery on horse clam.* The potentially high value of the live product will almost certainly lead to more requests to develop both a targeted dive fishery and an inter-tidal, land-based fishery. Development of either of these fisheries would require minimal additional capital outlay. The Subcommittee anticipates that the assessment-management framework currently used for the geoduck clam could be applied to horse clam, **but notes that considerable additional resources would be required for the assessment, management and enforcement of any new fishery**. In anticipation of developing a new fishery, the Subcommittee recommends that horse clam be identified as a high priority for the phased approach to fisheries development (Perry 1996).

Octopus: Octopus are fished in directed dive and trap fisheries, and incidentally in trap fisheries for prawn and crab and in trawl fisheries. There is no license limitation and no effort control in this fishery. Octopus has been largely used for bait in the halibut fishery, but there is increasing interest in food octopus for European and Asian markets. Interest is particularly high in the dive caught octopus in southern inside waters (larger octopus), and in northern trap fisheries. There is industry interest in using large freezer boats to produce higher quality product for the food-market, and in the development of selective octopus traps that would not retain prawns, and which would allow trap-fishing for octopus during prawn closures. Both proposed developments indicate a heightened interest in octopus, particularly as a food product. Fishery performance in other areas of the world is thought to be uniformly poor. For this reason and because of the potential for expansion in this fishery, the Subcommittee recommends:

1. that octopus be identified as a high priority for the phased approach to fisheries development (Perry 1996),
2. the imposition of license limitation in directed fisheries, and
3. that it is important to begin collection of bycatch information from current, observer-monitored, trawl fisheries.

Opal squid: The fishery for opal squid (*Loligo*) is currently a small and low value fishery. The product is used largely for bait, particularly in the crab fishery. This fishery has seen a rapid escalation in the number of licenses issued, but no increase in the number of license holders reporting catch. This suggests that catch is under-reported and that there is speculation in licenses, in anticipation of the imposition of effort controls. Because many current license holders report no catch, and because entry to the fishery is unlimited, the squid fishery is similar to other invertebrate fisheries in that rapid escalation in catch is possible. The opal squid is at the northern extent of its natural range in B.C., so our squid populations are likely not as productive as populations to the south. It is also an established tenet of conservation biology that populations at the limits of a species range are of particular significance. The Subcommittee recommends:

1. that opal squid be identified as a high priority for the phased approach to fisheries development so that data requirements for development of this fishery are formalized in anticipation of future requirements,
2. that license limitation be implemented in this fishery.

Goose barnacle: This is another species where value of live product is high in some European markets. About 10% of the licenses issued are reporting catch and the Subcommittee notes that there may be considerable unreported catch in this fishery. Data that are available show a declining catch per unit effort (CPUE), while those

engaged in the fishery report a declining abundance of suitable product. There are persistent requests for the approval of a dive fishery, which indicates continuing interest in the expansion in the harvest of this species. There have been requests by some First Nations to manage goose barnacles as part of their inter-tidal clam fisheries. The Subcommittee recommends:

1. that license limitation be imposed on this fishery, and
2. that DFO explore mechanisms for improving information on actual harvest levels.

Scallop: Although the number of licenses in the scallop fishery has been constant for the past 4 years, landings have slowly increased over that period, indicating a steady demand for this product. Many of the licenses are not reporting catch, indicating to the Subcommittee a potential for escalation in this fishery. Examination of logbook information collected in the fishery, as recommended by the Subcommittee last year, has indicated no conclusive evidence for declining abundance of scallop, although the analyses were completed at a coarse spatial scale. There continue to be reports from the fishery of localized depletions (e.g. Area 29-5). The Subcommittee recommends:

1. that because of possible local depletions and the potential for escalation in this fishery, that license limitation be instituted, and
2. that analysis of the logbook data be continued at a finer spatial scale to delimit areas of possible excessive harvest.

Other Issues Arising Out of the Fishery Updates

Geoduck: Geoduck is currently the most valuable invertebrate fishery in B. C., with landed values exceeding $36M. Two issues were identified in the Fishery Update. The first involves DFO's decision not to extend a license fee offset to G-license holders. This may lead to reduced industry support for assessment and management activities. This issue highlights the continuing need to develop partnerships and long-term, stable funding programs for assessment programs in all species. The second issue involves enhancement activities that have been undertaken by the Underwater Harvesters' Association (UHA). The Sub-committee notes that a seeding plan (including a design that will permit an evaluation of the activities) has not been provided to DFO. The Subcommittee advises that the proponents have some expectation of deriving benefits from these enhancement activities if they are successful. These benefits have not yet been made explicit by the UHA.

The Subcommittee recommends that a working group be established to evaluate, in concert with industry and other potential stakeholders, a strategy for incorporating geoduck enhancement activities already underway into assessment and management protocols for geoduck.

The Subcommittee advises that successful geoduck enhancement may entail future changes to established protocols for geoduck assessment and management.

Inter-tidal clams: Approval for "clam reform" has been granted and the new management framework is slated for introduction on January 1st, 1998. The new framework is based on limited entry, community based management boards, and increased First Nations involvement. The Subcommittee notes that a pilot project in License Area C, which implemented limited entry, and First Nations and community involvement in management, has provided increased opportunities for the controlled fishing opportunities, and for improved monitoring of the fisheries.

The Subcommittee notes that reduced landings of clam in 1996 do not necessarily reflect changes in stock status but rather may reflect more restrictive management actions.

The Subcommittee notes that despite improvements in the record keeping on enforcement actions, DFO remains unable to quantify illegal clam removal in all areas. Undocumented harvest continues to severely limit progress in developing biologically based approaches to clam management, and given the increasing extent of areas closed because of fecal coliform contamination, may pose a growing health risk. The Subcommittee recommends that ongoing dialog with the Province, concerning the development of effective enforcement procedures, be strongly supported.

The Subcommittee notes that a Japanese exotic (Varnish clam) is spreading rapidly in the southern coastal area and recommends that data-sharing between DFO, BC and industry be formalized so that the situation can be monitored and as a prelude to the provision of advice on emerging concerns.

The Subcommittee notes the increasing extent of areas closed to harvest because of contamination around the Strait of Georgia. The Subcommittee notes that closures force legal harvest into smaller areas, intensifying pressure on wild stocks. The Subcommittee recommends that efforts to reverse this trend involving all levels of government and the public be intensified.

Green sea urchin & sea cucumber: Development of both of these fisheries is proceeding in an orderly and scientifically rigorous manner. The Subcommittee notes that this progress is due to the commitment of all DFO sectors and industry to an open and cooperative process formalized by the phased approach to the fisheries development (Perry 1996).

Appendix 1. Participants at Invertebrate Subcommittee Meeting July 7-10, 1997.

NAME	AFFILIATION
B. Adkins	Pacific Region Shellfish Coordinator
J. Bond	Stock Assessment Division (StAD), PBS
J. Boutillier	Head, Shellfish Section, StAD, PBS
A. Campbell	StAD, PBS
G. Gillespie	StAD, PBS
C. Hand	StAD, PBS
W. Heath	BC Ministry Agriculture, Fisheries & Food
S. Heizer	Fisheries Management (FM), SCD
B. Holtby (Chair)	StAD, PBS
M. Joyce	Treaty Negotiations, AFS
M. Kattilakoski	FM, SCD
R. Kronlund	StAD, PBS
R. Lauzier	StAD, PBS
K. Marcus	FM, SCD
S. McKinnell (Reviewer)	Ocean Sciences, PBS
J. Morrison	FM, SCD
G. Parker	FM, SCD
I. Perry	StAD, PBS
A. Phillips	StAD, PBS
K. Southey	FM,. SCD
B. Waddell	StAD, PBS
R. Webb	Operations Branch, SCD
K. West	FM, FRD

Appendix 2. Reviewers of Working Papers.

NAME	AFFILIATION
N. Bourne	Aquaculture, PBS, Nanaimo (retired)
R. E. Elner	Canadian Wildlife Service, DOE, Delta, B.C.
G. Gillespie	StAD, PBS, Nanaimo
R. Hannah	Oregon Dept. Fish and Wildlife, Newport, OR
S. Ignell	Alaska Dept. Fish and Game, Kodiak, AK
R. Kronlund	StAD, PBS, Nanaimo
R. Lauzier	StAD, PBS, Nanaimo
B. Leaman	StAD, PBS, Nanaimo
S. McKinnell	Ocean Sciences, PBS, Nanaimo
D. Pengilly	Alaska Dept. Fish and Game, Kodiak, AK
I. Perry	StAD, PBS, Nanaimo
R. Tanasichuk	StAD, PBS, Nanaimo
M. Tegner	Scripps Inst. Oceanography, UCSD, San Diego, CA

Appendix 3. Invertebrate landings in British Columbia, 1981 to 1996.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995*	1996
INTERTIDAL CLAMS - Commercial Fishery:																
Razor	30	68	31	100	90	142	142	155	117	114	117	55	44	105	140	76
Butter	120	103	77	130	251	158	68	134	92	109	42	132	102	174	101	99
Manila[1]	317	597	1048	1677	1913	1893	3607	3909	2764	1456	982	914	1059	1376	1292	1041
Nat. Ln.	179	241	324	294	191	284	373	290	433	465	201	116	131	94	140	72
Mixed	161	155	279	410	477	371	87	27	159	339	137	124	133	87	3	2
SubTotal: Commercial Fishery	807	1164	1759	2611	2922	2848	4277	4515	3565	2483	1479	1341	1469	1836	1676	1290
FARMED CLAMS					4	7	25	30	31	39	169	300	300	500	885	1000
TOTAL INTERTIDAL CLAMS	**807**	**1164**	**1759**	**2611**	**2926**	**2855**	**4302**	**4545**	**3596**	**2522**	**1648**	**1641**	**1769**	**2336**	**2561**	**2290**
GEODUCK	2704	3135	2636	3483	5370	5006	5734	4567	3985	3956	3333	2864	2455	2235	**2061**	**1841**
HORSE CLAM	51	321	21	7	6	96	355	325	115	124	110	2	23	62	1	
SHRIMP	581	413	411	408	678	768	2644	2561	2299	1940	3265	2683	3283	3192	6780	7436
PRAWN	358	274	331	505	514	550	620	720	820	761	961	1168	1215	1309	1300	1710
CRAB [3]	1317	1003	960	1155	1165	1321	1631	1508	1522	2168	1887	3355	6306	6002	4594	4942
ABALONE	85	82	56	58	42	52	49	49	49	50	N/A	N/A	N/A	N/A	N/A	
OCTOPUS		18	30	25	32	53	129	209	217	198	131	117	145	72	74	130
SEA URCHIN	116	160	986	1764	1815	2067	2223									
RED								2116	2658	3158	6945	12018	6388	5829	**6255**	**6272**

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995*	1996
GREEN [4]								444	609	475	607	1042	714	332	87	142.8
SEA CUCUMBER[2]				113	346	786	1722	1922	1144	870	1340	1242	812	556	588	350
SCALLOP		8	11	18	53	68	66	67	75	69	82	91	90	104	93	100
PLANKTON	19		47	103	131	166	130	247	360	530	450	380	53	333	579	507
SQUID		29	15	69	111	79	86	88	70	72	116	93	13	175	78	71
MUSSELS			tr	1	tr	2	2	3	4	1	tr	0	0	0	0	0
GOOSENECK BARNACLES					tr	2	32	49	30	37	40	38	30	19	7	12
OYSTERS - Farmed		1579	2453	2897	3420	2864	3482	3702	3721	4547	4482	4500	4000	4900	5300	5700
TOTAL TONNES	6038	8186	9716	13217	16609	16735	23207	23122	21274	21478	25397	31234	27296	27456	30358	31504

* preliminary landings for 1995 and 1996

[1] the sum of commercial fishery landings, depurated and Aboriginal licensed harvest, and not including production from clam tenures

[2] landings are round weight

[3] crab landings include Tanner, king, other and dungeness crabs (1989 to 1996)

[4] green sea urchin landings in 1995/96 taken from validation logs

Appendix 4. Landed value of invertebrates in thousands of Canadian dollars in British Columbia, 1981-1996

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995*	1996*
INTERTIDAL CLAMS - Commercial Fishery:																
Razor	24	55	24	123	95	127	126	137	124	130	129	82	67	186	247	135
Butter	42	36	33	55	138	75	40	63	44	53	34	81	60	103	71	70
Manila	323	611	1043	1813	2278	2762	6003	7175	6003	3761	2574	2253	2761	3776	4158	3628
Nat. Ln.	195	263	329	311	202	327	474	359	588	710	327	193	212	147	241	129
Mixed	175	169	293	455	575	510	132	36	196	625	238	252	271	198	7	6
SubTotal: Commercial Fishery:	759	1134	1722	2757	3288	3801	6775	7770	6955	5279	3302	2861	3371	4410	4724	3968
Farmed Clams:					4	14	43	59	96	140	556	1000	1200	1900	3885	4750
TOTAL INTERTIDAL CLAMS	**759**	**1134**	**1722**	**2757**	**3292**	**3815**	**59**	**7829**	**7051**	**5419**	**3858**	**3861**	**4571**	**6310**	**8609**	**8718**
GEODUCK	2434	2814	1818	2937	4605	4294	6184	9762	12967	10582	9659	16237	26994	33426	42518	36175
HORSE CLAM	42	235	12	5	6	63	309	300	144	274	119	2	46	111	2	0
SHRIMP	912	644	1073	1022	1180	1240	4609	2802	2985	2637	4430	2831	3494	4772	13796	11644
PRAWN	2019	1545	2138	3262	3379	3734	4326	5724	7083	7006	7728	8380	10121	12133	17752	25891
CRAB	3556	2345	3320	4558	4719	5661	6452	5945	6088	9311	8688	11203	18761	25686	23562	23395
ABALONE	721	696	462	530	442	734	973	1076	1170	1347	N/A	N/A	N/A	N/A	N/A	N/A
OCTOPUS		39	63	56	82	136	381	651	707	657	415	350	447	231	269	467
SEA URCHIN	34	56	358	712	763	1011	1276									
RED								1241	1631	1953	4187	8660	5271	8038	11269	12199
GREEN								584	1020	948	1795	4424	3777	2122	648	921

SEA CUCUMBER				22	94	236	768	961	998	1168	1029	1363	982	1035	947	647
SCALLOP		17	24	56	95	212	244	285	316	317	387	420	423	490	465	493
PLANKTON	6	0	19	42	89	113	102	192	223	415	390	318	41	259	369	465
SQUID		22	21	84	184	127	132	113	94	81	148	135	17	199	97	87
MUSSELS		tr	tr	tr	0	tr	tr	tr	tr	1	tr	0	0	0	0	0
GOOSENECK BARNACLES					1	4	211	479	343	413	418	448	320	181	71	112
OYSTERS - Farmed		981	1554	2109	2613	2515	2548	2725	2938	3613	3465	3600	4700	4500	5500	6000
TOTAL VALUE ($000)	**10483**	**10528**	**12584**	**18152**	**21544**	**23895**	**28574**	**40669**	**45758**	**46142**	**46716**	**62232**	**79965**	**99493**	**125874**	**127214**

*preliminary values for 1995 and 1996

[1] the sum of commercial fishery values, estimated depurated and Aboriginal licenced harvest value, and not including production from clam tenures

[2] landings include tanner, king, other and dungeness crabs (1989 to 1996)

[3] value estimated from sales slips for 1995/96

Appendix 5. Management framework for invertebrate fisheries, 1997.

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
Geoduck	Limited entry, 55 'G' licenses with equal I.Q.'s, divided into 3 license areas . Vessels may have up to 3 tabs. License conditions include industry funded fishing notification, catch validation and catch reporting.	1997 quota reduced to 1799.5 t for I.Q.'s of 32.7 t . plus 3.3 t for biological samples	Varies by area - with market and psp concerns. Primarily live market with highest demand in Dec/Jan. Harvest for processing in psp closed areas requires a permit and decontamination plan - none issued to date	Fishery areas are in a three year rotation. Quotas calculated based on an annual yield of 1% of virgin biomass. Harvest log and validation log combined in one form since 1995, funded by license holders.
Horse Clam	Limited to geoduck licenses only (55)	A non-directed incidental fishery with catch ceilings set by area.	Open concurrent with geoduck fishery to allow incidental catch of horse clams	Concerns about harvest practices disrupting eelgrass and unknown horse clam biomass limit fishery development.
Green Sea Urchin	Limited entry - 49 'ZA' licenses. Equal I.Q.'s and licenses transferable since 1995. License conditions include industry funded fishing notification, catch validation and catch reporting.	South coast quota 166 t. with equal I.Q.'s of 3.38 t per license North coast - with exploratory protocol on request.	License year June 1/96 to May 31/97. Fishery open mid Nov through the end of Jan in 1996/97.	Market peak in Dec/Jan. Minimum size limit in effect Considered a data-limited fishery. Previously unharvested areas to be fished with exploratory protocol.
Red Sea Urchin	Limited entry - 105 'ZC' licenses plus 4 'F' (Aboriginal). Two license areas. Equal I.Q.'s. License conditions include industry funded fishing notification, catch validation and catch reporting.	1.5 year 1997/98 quota set at 9851.4 t or I.Q.'s of 89.5 t per license, form Jan 1/97 to June 30/98.	Openings scheduled to accommodate year round market supply in the north, scheduled at request in the south, usually through peak markets of fall and winter	License year end change to be effected July 1/98 to June 30/99.
Sea Cucumber	Limited entry - 85 'ZD' licenses eligible in 1996. Area Licensing. Equal I.Q.'s. Maximum 3 licenses per vessel. License conditions include industry funded fishing notification, catch validation and	1996 I.Q.'s set at 6049 lb. (2.75 t) per license, 4 license areas - total coastwide quota unchanged at 233 t split weight.	Opened Oct 7, 1996, for 2 weeks in all areas.	Four license areas in 1996 - Queen Charlottes closed, however expected to re-open in 1997 with five license areas. Data-limited fishery. Science recommendations for non-rotational fishing areas, with large permanent

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
	catch reporting.			closures and experimental fishery areas.
Goose Barnacle	Non-limited 'Z6' license - 56 issued in 1996	none	all year	Less than 10% of the stock estimated to be available for harvest due to harvest conditions or market quality demands
Pink and Spiny Scallop (trawl)	Non-limited 'ZR' license issued to 40 vessels in 1996	none - limited by minimum size limit	all year except for psp and permanent closure areas	limited by market, must land at a registered shellfish plant, industry participation in PSP monitoring program in 1996 and 1997.
Pink and Spiny Scallop (dive gear)	Non-limited 'ZI' license issued to 39 vessels in 1996	none - limited by minimum size limit	all year except for psp and permanent closure areas	limited by market, must land at a registered shellfish plant, industry participation in PSP monitoring program in 1996 and 1997 at key dive sites
Plankton- Euphausiids	Limited entry - 18 'ZF' licenses issued in 1996. Industry funded notification and catch validation implemented by license condition in 1997.	500 t total - 275 t in mainland inlets and 215 t strait of Georgia	Inlets open Jan to Mar, Aug to Oct. or until area quotas are landed Strait of Georgia Nov 1 to Dec 31	
Octopus (by Trap)	Non-limited 'ZP' license issued to 233 vessels in 1996	none	Inshore: open April to Dec in times and areas open to prawn fishing.	Few directed octopus by trap fishers, largely landed as incidental catch in other trap fisheries. Growing interest in a food rather that a mainly bait market.
Octopus (by Dive)	Non-limited 'ZG' license issued to 64 vessels in 1996	none	Open all year with seasonal closures for spawning. Some park and reserve closures in effect	Must be vessel based harvest, Market has been limited, but a growing interest in a food rather that mainly bait market.
Prawn Shrimp (by Trap)	Limited entry, 257 'W' licenses with equal trap limits, Vessels may fish either one trap allocation (300 traps) or two (450 traps). Industry funded on-grounds monitoring.	Time and area closures based on a minimum escapement of the spawner cohort. Minimum size limits, gear escapement regulations	Seasonal closure January to April/May In 1996, the fishery closed coastwide on Aug 16/96 to April 15/97	Increased monitoring and increased effort has resulted in earlier closures. Special Management areas maintained with separate open times and increased gear restrictions.
Shrimp Trawl	Limited entry, 247 'S' licenses plus 2 'F' (Aboriginal) licenses eligible in 1996. 1997 changes include Industry funded catch and by-catch monitoring .	From an offshore only quota of 500 t up to 1996, catch ceilings implemented in many areas for 1997	Traditionally open all year except for navigational, by-catch, reserve closures. Closures in 1997 to be implemented as catch ceilings are met.	Increase in catches in 1995 and 1996 have led to serious conservation and By-catch concerns. As a result, there were significant changes recommended for this fishery in 1997.

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
			No prawn retention in areas closed to prawn fishing	
Opal Squid	Non-limited 'ZE' license issued to 107 vessels in 1996	none	permanent closures in a number of areas	
Crab	Limited entry, 224 'R' licenses eligible in 1996. Area licensing.	Managed by minimum size limit, area specific trap limits, soft-shell closures, trap escapement regulations	Area closures for soft-shell, dioxins, allocations to aboriginal or sport harvest	Non-retention of females. Rot panel and escapement port requirements for traps,
Inter-tidal Clam	Non-limited 'Z2' license issued to 1906 persons in 1996. Area licensing since 1989.	Managed by minimum size limits and a set TAC at Savary Island	seasonal openings and closures with openings staggered in an attempt to maintain market supply. Allocation closures for aboriginal and recreational fisheries.	Ongoing consultation through 1996 - recommended license limitation criteria to be implemented in 1998, along with the establishment of Community Clam Management Boards and specific Aboriginal fishery opportunities. Clam depuration harvest increased.

Appendix 6 Abstract of Perry, R. I. 1996. A *framework for providing* scientific advice for the management of new and developing invertebrate fisheries, PSARC Working Paper I96-6.

A framework is developed for the provision of scientific advice to support the management of new and developing (i.e. data-limited) invertebrate fisheries. The framework explicit endorses the precautionary approach to fisheries management and research. Information on the abundance, distribution, and productivity of the target species is identified as the key scientific requirement for development of precautionary management strategies. Three "phases" are proposed to obtain this information:

(a) Phase (0) "collection of existing information", consisting of a search for available formal (and anecdotal) information on the target species (and similar species) and application of a "meta-analysis";

(b) Phase (1) "fishing for information", consisting of surveys to obtain essential information that is insufficient or lacking in the Phase (0) analysis, and which must be based on a formal, statistical sampling design; and

(c) Phase (2) "fishing for commerce" which consists of closely monitored fishing operations to increase the information base available, to refine the results form Phase (1) activities, and to probe the stock's response to fishing.

The roles and importance of modeling, uncertainty, additional biological studies, and the establishment of no-fishing reference area are also recognized. Throughout this framework, strong interaction and collaboration among science, management, and stakeholder activities is crucial to the provision of scientific advice for precautionary fishery management.